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OF RECENT DEVELOPMENTS

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PROPERTY STUDIES OF COATED COLUMBIUM AND TANTALUM ALLOYS

NASA Langley has investigated protection of Ta-10W alloy by the slurry Sn-23.5Al-Mo coating.⁽⁸⁾ The coating provided protection for about 2 hours in static air at 2900 F. Flowing air (subsonic) reduced the lifetime by a factor of four. Addition of more molybdenum (7 compared with 5.5 percent) appeared to give some increase in life in flowing air. Use of 6-minute cycles reduced the lifetime by a factor of two in static air. The coating caused little change in substrate tensile strength and elastic modulus at temperatures up to 2900 F even after 5 hours' exposure at 2600 F. However, room-temperature elongation of 0.008-inch-thick sheet was reduced by about a factor of two, and 0.025-inch-thick sheet was somewhat less affected. Elongation was about 10 to 20 percent at 2000 to 2900 F, and about 5 percent at 1700 F. Prior exposure for 5 hours at 2600 F reduced the tensile elongations to 1 to 7 percent. Limited tests indicated that graded intermetallic/oxide coatings (MoSi₂ or WSi₂/stabilized ZrO₂) have good spalling resistance after cyclic oxidation.

The performance capabilities of fused-slurry, complex silicide coatings on columbium alloy sheet has been evaluated by Lockheed-California.⁽⁹⁾ Sylcor R512E (20Cr-20Fe-60Si) protected Cb-752 alloy over 8 hours at 2600 F at 0.1 torr, and over 8 hours at 2800 F at 1 and 10 torr air pressure. The system survived twenty 2.2-hour cycles of temperature up to 2500 F and pressures of 0.01 to 1000 torr, which simulated reentry conditions. Temperature capabilities of similar systems Cb-752/R512A (20 Cr-5Ti-75Si), D-43/R512A, and D-43/R512E appeared to be about 100 F lower.

McDonnell-Douglas is also evaluating the system Cb-752/R512E under temperature (up to 2600 F) -pressure (10⁻⁴ to 25 torr)-stress (0-40,000 psi) -time profiles representative of hypersonic flight.⁽¹⁰⁾ Particular attention will be given to joints, faying surfaces, defect sensitivity, and reuse capability of spacecraft hardware.

McDonnell-Douglas is developing self-sustaining, radiating, coated tantalum-alloy structures for operation to 3600 F.⁽¹¹⁾ Oxidation-resistance and room- and elevated-temperature mechanical-property tests are being conducted on various systems, including T-222 tantalum alloy and Solar (95W-5Ti)-Si and Sylcor W/WSi₂ coating systems. Fabricability tests are being conducted with the intention of eventual testing of full-scale leading-edge and flat-panel components.

Fundamental processes involved in the protection of columbium and tantalum by their silicides are being studied at the City College Research Foundation.⁽¹²⁾ The program consists of four parts: (1) establishment of thermochemical data for silicides employing an entirely solid-state electrochemical cell, (2) protection of both coating and substrate by glasses formed during oxidation, (3) use of coating modifiers to promote the formation of glassy films, and (4) interactions between intermediate phases, coating, and substrate, and the use of diffusion barriers to retard growth of intermediate phases.

A portion of a recent University of Dayton Research Institute effort was concerned with evaluation of D-43/R512A silicide and Cb-752, WC-103, and WC-129/Vac-Hyd Lunite 2 aluminide.⁽¹³⁾ The as-coated D-43 columbium alloy retained full bend ductility to -60 F and showed no evidence of room-temperature embrittlement after 30 hours in static air at 2600 F. The excellent throwing power of the silicide was evident by complete penetration of spot-welded lap joints. Lifetimes of 12 and 23 hours at 2600 F at 95 percent reliability were found for the 2.75- and 4.4-mil-thick coating, respectively. Somewhat better performance was noted at 2400 F. In contrast, the Lunite 2 and modified Lunite 2 (ND 66-1) coatings failed in less than 2 hours at 2600 F and survived about 2 to 5 hours at 2400 F.

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* These references were covered in detail in DMIC Memorandum 227, which is available on request to qualified DMIC users.

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